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ABSTRACT

A school district's program coordinator designed and implemented a practicum study intended to provide intermediate grade teachers and students with problem-solving techniques and skills needed for success in a course in contemporary Canadian issues. Teachers' and students' problem-solving skills were assessed through reports based on teleconferences, questionnaires, teacher observations, and results of student tests and projects. It was concluded that a comprehensive list of heuristics for devising problem-solving strategies coupled with a model for emulation would provide the direction teachers and students needed. A series of workshops used role-playing, modeling, peer tutoring, and practice as means of remediating deficiencies in teachers' problem-solving skills. Only after the workshops, and then under supervision, did teachers introduce the skills in class. Analysis of practicum evaluation data revealed that problem-solving skills of teachers and students had increased. Teachers reported that the model simplified processes and provided structure and direction. Students reported that the model removed uncertainties in the problem-solving process. As a result of the practicum, the problem-solving model has been incorporated into the curriculum for intermediate students. Teacher interview questions, the problem-solving model, a list of criteria for acceptable modeling, and other related materials are appended. (RH)

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A Model for Improving the Teaching of Problem-Solving at the Intermediate School Level

by

Philip Cull

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A Practicum I Report presented to the Ed.D. Program in Early and Middle Childhood in Partial Fulfillment of the Requirements for the Degree of Doctor of Education

NOVA UNIVERSITY

1989

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PRACTICUM APPROVAL SHEET

This practicum took place as described.

Verifier: William Carter
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Superintendent of Education
(Title)

Bonavista-Trinity-Placentia Integrated School Board, Clarenville, NF CANADA AOE 1JO

December 18, 1989
Date

This practicum report was submitted by Philip Cull under the direction of the advisor listed below. It was submitted to the Ed.D. Program in Early and Middle Childhood and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Nova University.

Approved:

March 5, 1990
Date of Final Approval of Report

Polly Peterson, Ph.D.
Polly Peterson, Ph.D., Advisor

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ABSTRACT

A Model for Improving the Teaching of Problem-Solving at the Intermediate School Level. Cull, Philip, 1989: Practicum Report, Nova University, Ed.D. Program in Early and Middle Childhood. Descriptors: Problem-Solving/Thinking Skills/Critical Thinking/Problem-Posing/Metacognition/ Problem-Solving Heuristics/Inquiry Learning.

This practicum was designed to provide teachers and their students with the problem-solving techniques and skills necessary for success in a problems course. A second aim was to develop a repertoire of problem-solving techniques that would have trans-curricular application.

Teachers' and students' problem-solving skills were determined through reports from teleconferences, questionnaires, teacher observations, and student tests/project results. It was determined that a comprehensive list of heuristics for devising problem-solving strategies coupled with a model for emulation would provide the direction needed for the teachers and students. This was followed by a series of workshops which used role-playing, modelling, peer tutoring, and practice as a means of remediating the deficiency in teachers' problem-solving skills. Only after successfully completing the workshops were the skills tried at the classroom level and then under supervision.

Analysis of the data revealed that the problem-solving skills of both teachers and students had increased. Teachers reported that the model simplified the process and at the same time provided structure and direction. Students reported that the model removed the uncertainties in the problem-solving process. As a result of the practicum, the problem-solving model has been formally incorporated into the curriculum for intermediate students.

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Chapter 1

INTRODUCTION

Description of Work Setting

The work study area is a school district in a rural Canadian setting of approximately 6000 square kilometres. The school district maintains twenty-three schools, a resource centre, and a central office complex. Fifteen of these schools are located in small, semi-isolated fishing villages. The remaining eight schools, and the central office, are located in larger communities.

Central office personnel, who are charged with the responsibility for implementing provincial programmes and policies, are comprised of twenty-four professional and support staff. There is one superintendent of education, three assistant superintendents (one responsible for curriculum, one for personnel, and the other for administration), nine curriculum specialists known as programme co-ordinators, one educational psychologist, one business administrator and nine support staff.

The central office complex and headquarters for the writer is located in a town of approximately 5000. This

settlement originated from the amalgamation of several small logging and sawmilling communities which had been settled in the mid-1800s. Located at the head of a long picturesque fiord, it has evolved into the transportation and service centre for the region. Boatbuilding, asphalt/cresote manufacture, oil refining and tourism have all been significant aspects of the regional economy. The community is adjacent to a national park, ski resort, and an assortment of other cultural/recreational facilities.

The Writer's Role

The writer's responsibilities as a programme co-ordinator necessitate at least four-fifths of work time spent in schools and one-fifth at the central office. The duties performed as programme co-ordinator include the following:

1. Visits classrooms and works with teachers on instructional and curricular matters peculiar to social studies;
2. Chairs district (sometimes provincial) curriculum committees;
3. Assists in evaluating the quality of teaching and learning;
4. Assists in the enrichment of social studies programmes;
5. In-services teachers in new programmes and teaching techniques;

6. Monitors the quality and quantity of student evaluation procedures;
7. Assists in diagnosing and developing programmes to meet the needs of teachers;
8. Assists in developing a consistent philosophy of education;
9. Assists in the recruitment, selection, orientation and assignment of new teachers; and
10. Assists in the formative evaluation of teachers.

The district programme co-ordinator is expected to answer a local subject-area need by providing expertise in curriculum and instruction. The role requires the co-ordinator to keep teachers updated on curriculum changes, new approaches to methodology and teaching strategies, new techniques for proper assessment and placement of teachers, and continued improvements in the ongoing evaluation of student progress.

Chapter II

STUDY OF THE PROBLEM

Problem Description

In September, 1988, the Department of Education established a social studies programme that focused on contemporary Canadian issues. Nine pilot schools were selected which were deemed to be representative of the kinds of schools found in the province. These schools were given a mandate to field-test the material during the 1988-89 school year.

During the course of the field-testing procedure, it was discovered that both the teachers and students were having difficulty with problem-solving techniques and skills. Given that this course is a "problems course", the pilot programme almost ground to a standstill.

During a January 30, 1989 workshop, and a February 16, 1989 teleconference, the teachers expressed their concerns and brainstormed as to why the problem existed. The consensus that emerged was that they were predominately "lecture types" and had not been exposed to problem-solving-inquiry types of methodologies in their teacher training. Consequently, if the teachers did not employ the use of these methodologies, it therefore followed that the students under their direction would not exhibit proficiency in this area.

Table 1

Proficiency of Students in Problem-Solving as Measured by Teacher-made Tests
N = 360

Percentage of Proficiency	Number
60 - 100%	0
50 - 60%	40
40 - 50%	260
30 - 40%	60

District Mid-year Results, 1989

The problem, then, was that teachers who had not been trained in how to incorporate problem-solving techniques into their teaching were charged with the responsibility of teaching "a problems (issues) course" to their students.

Consequently, they concluded that they were unable to fulfill their mandate in this regard.

Problem Documentation

Teachers expressed their concerns and brainstormed as to why the problem exists during a January 30, 1989 workshop, and a February 16, 1989 teleconference. The consensus that emerged was that this type of training was not a part of their university/college teacher training program.

This problem has been acknowledged by several studies between 1987 and 1989. In 1987, a Teacher Education Review Committee pointed out that the methodologies presented to student teachers are "product/expository (closed) by design .... however, in the field, programmes are being developed that reflect the process of learning as a way to utilize a more comprehensive understanding of content.

This process reflects the open lesson approach, i.e. case study, inquiry-problem-solving (open), role playing, etc." (pp. 6 - 7). Many teachers describe themselves as being from "old school" where the teaching of content specific information was an acceptable practice. They have become comfortable in the existing practice of lecture-taking notes approach and the regurgitation of information from the same. The move to an open person approach involving problem-solving will require the new focus for many teachers.

Causative Analysis

In 1987, a second Teacher Education Review Committee pointed out that "... teacher training has not kept abreast with research development and the needs of educators in the field. Graduates are being exposed to content and methodology which may not even have been appropriate twenty to twenty-five years ago" (p. 2). The institutions responsible for teacher training have acknowledged the problem and their role in its development. (Gazette, 1989 [March 30], pp. 1 - 2; Report of the Presidental Committee to Review Teacher Education, 1989 [November], pp. 31 - 36).

Burns and Lash (1988) point out that there are several reasons why problem-solving instruction might cause more difficulties for teachers.

> First, pedagogical content knowledge (knowledge about how to teach specific subject matter) decisions may be more difficult for problem-solving instruction. Although ... teachers generally agree that 'drill and practice' are necessary for basic skills instruction, it is less clear how problem-solving should be taught. Second, the greater difficulty of problem-solving materials increases the pressure on teachers to teach the material in a way that produces the fewest difficulties for students and fewest management problems for themselves. (pp. 370 - 371)

Thus, the cause for the lack of problem-solving skills is that teachers were never trained in the technique. Their teaching have been content specific and 'drill and practice'. Faced with a situation were the volume of information available to teachers and students is mushrooming at an alarming rate, techniques utilizing the processes of learning must be foremost in teaching. The process technique that appears to be the most neglected because of deficiencies in teacher training courses is that of problem-solving. This omission appears to be particularly serious considering the view of Kindersvatter, Wilen and Ishler (1988). They make the claim that "... perhaps the single most significant statement in the literature related to decision-making. This statement made the claim that problem-solving was 'the' basic teaching skill. It is a statement which stands unchallenged because it is self-evident" (p. 4).

Relationship of the Problem to the Literature

The major concerns that underlie the discrepancy between the programmes and the expectations of teachers, given the school curriculum they are expected to deliver, are with student performance.

During the last decade, there has been an increasing emphasis on teachers' thought processes in the study of teaching and learning (Clark and Peterson, 1986; Shavelson and Stern, 1981) that has illustrated the global nature of

the problem. This research on cognition and problem solving has provided a framework for evaluating teachers' knowledge and their ability to assess their students' thinking.

The type of problem-solving deficiency has been expounded upon by Ross and Maynes (1982, p. 3):

> Pre-service training, professional development sessions and teacher journals all provide practical ideas for providing content instruction. In contrast, practical ideas on how to teach problem-solving are relatively scarce. Few teachers can claim expertise on this dimension because the technology for teaching problem-solving effectively is so recent; it comes out of advances in cognitive psychology in the last few years that have not yet been translated into feasible directives for classroom practice. Teachers who try to teach problem-solving without recourse to this developing technology find that their efforts are much less successful than they would hope: the bright students benefit but somehow the instruction goes over the heads of the average and slower groups. Good teachers who try to make classes interesting and meaningful for all ability levels, and who are conscious of their own greater competence in content teaching, naturally move away from the problem-solving dimension.

Gagné (1977) and Graves (1984) have placed the dimension of problem-solving into a theoretical framework for teaching and learning. Both writers claim that there are eight types of learning which require different 'conditions of learning'. Each type of learning is of a different order of complexity from the others, and all eight may be arranged in a hierarchy, starting with 'signal learning' at the bottom and culminating in 'problem-solving' at the top.

They suggest that when a student is engaged in a problem-solving operation, it is necessary for him "to have learned certain rules, to have acquired certain related concepts, which themselves have had to be learned through a process of discrimination, and such a process is dependent on the student having learned a series of 'chains or associations' (verbal or non-verbal) which are themselves dependent on learned 'stimulus - response connections' which may or may not be the result of 'signal learning'" (Graves, 1984, p. 181).

"Problem-solving for Gagné is the ability to use the 'rules' and concepts at one's disposal to tackle situations which are new to the learner and require thinking out." (Graves, 1984, p. 183) Thus, problem-solving, although at the top of the learning hierarchy, may itself be at many different levels.

Much of the recent research on thinking and problem solving has focused on performance in specific, semantically

rich content domains. This research has generated detailed descriptions of knowledge and problem-solving processes that can serve as a basis for analyzing teachers' pedagogical content knowledge. One major strand of research has focus on students' solutions to different types of problems by examining their developmental levels (Carpenter, 1985, Carpenter and Moser, 1983; and Riley, Greene, and Heller, 1983). Although there are differences in details and emphasis, researchers have found remarkably consistent results over a number of studies; and "there is a general consensus about how [students] solve different problems that provide a basis for evaluating teachers' knowledge of their students' thinking" (Carpenter, Fennema, Peterson and Carey, 1988, p. 387).

Even with teachers and programmes that claim to address the skills of problem-solving, Beyer (1984) claims that "... in reality few do" (p. 229). He further states that these "... teachers and texts usually fail to provide students explicit, direct instruction in what these skills are and how to employ them. Many texts and teachers also fail to devote continuing attention to each skill introduced, erroneously assuming one exposure is enough for such skills to "catch". These failures doom most students and teachers to hit-or-miss teaching and learning ..." (p. 229).

Swety (1989) indicates how today's problems can be traced back several thousand years. "Often, the same concerns occupy modern-day students ... and this simple

realization, namely, the continuity of ... concepts and processes over past centuries, can help motivate learning" (p. 370).

In this context, problem-solving is seen as "a framework for interdisciplinary cooperation" (Rubinstein, 1980, p. 26).

Graebner and Dobbs (1984) found that "a team approach to problem-solving in the classroom ... helps troubled teachers and students" (p. 138).

Carpenter, et al. (1988) investigated the teachers' pedagogical content knowledge of students' problem-solving in elementary arithmetic. Ross and Maynes (1982) cite "science programs", "English" and geography" as having concerns about the "effective teaching of problem-solving" (p. 4). Kouba et al. (1988) analyzed the results of the National Assessment of Educational Progress and concluded that "problem solving continues to be an area of central concern" (p. 19).

Barrow (1981) points out that problems in every day living tend

> ...to be diffuse and complex, so that one ... very seldom faces a purely biological problem (for example) or a purely anything else problem. You face complex problems that draw on many subjects and disciplines, and consequently it is foolish to teach biology rather than to focus on actual complex problems (p. 110).

In the belief that this is a concern that should be addressed, Rubinstein (1980) established the rationale for the accentuation of problem-solving in the school's curriculum. He states that in previous generations

> ... stored knowledge could be passed on from generation to generation. In future, ... graduates will have to be retrained more than once in the span of a normal life. In the past, it was common for successive generations to subscribe to the same values. In the future, values may change more than once in a single generation. In an area of rapid social and technological change, education should develop a flexible and unsettled approach to life rather than a false sense anchored in a store of knowledge and fixed values. It should strive to cultivate modes of behaviour and attitudes useful in a world of constant change. A problem-solving approach to learning, with a focus on process, appeared most compatible with these objectives. Such an approach would help students transfer what is taught in school to relevant situations outside school by developing the ability to identify problems and to sort out the relevant skills and tools appropriate to deal with them (pp. 25-26).

Unless success is achieved in teaching critical thinking skills and problem-solving techniques, it is evident that students will be ill-equipped to cope with future changes. The focus on process should yield an additional bonus - the relief from the difficult task of having to teach 'the textbook' and memorize facts that may have little futuristic value.

Chapter III

ANTICIPATED OUTCOMES AND EVALUATION INSTRUMENTS

Goals and Expectations

Hamner and Organ (1978) state that "there seems to be no dispute that goal setting is a cause of performance" (p. 147). According to Fraenkel (1980), "a goal is broader and more long-range than an objective. It is something to strive for, to move toward, or to become. It is an aim or purpose so stated that it excites the imagination and gives people something they want for, something they don't know how to do, something they can be proud of when they achieve it" (p. 8). It is with this in mind that the following goals are presented:

1. To develop a general foundation of problem-solving approaches, and master some specific techniques.
2. To emphasize the thinking processes at all stages of the problem-solving activity.
3. To be able to use a model as a guide in the problem-solving process.
4. To teach the problem-solving process in the classroom.
5. To improve the problem-solving capabilities of teachers.

Instructional Objectives

Mager (1984) states that objectives are useful tools "... in pointing to the content and procedures that will

lead to successful instruction, in helping to manage the instructional process itself, and in helping to prepare the means of finding out whether the instruction has been successful" (p. 19). Thus, the instructional objectives that were used in the design, implementation, and evaluation of the problem-solving process were as follows:

Objectives for Teachers

1. Given a model for problem-solving be able to identify the steps in the problem-solving process without the aid of references.

For this first objective, teachers were given a blank outline of a seven-step model in the form of a means/ends block programme. Teachers were expected to fill in all seven-steps "without the aid of references".

2. Upon the completion of an inservice/seminar on problem-solving techniques, be able to role-model the methodologies with such a degree of proficiency that peers will be able to identify the steps in the problem-solving process.

Since it was the teachers themselves who first identified and alerted the central office to the problem, they participated in evaluating their own performance. After the inservice/seminar on problem-solving methodologies each teacher modelled a problem-solving situation. This performance was considered acceptable when each observing member could identify "the steps in the problem-solving process".

3. Upon completion of an inservice/seminar, and peer tutoring sessions, be able to demonstrate abilities in teaching problem-solving processes to students to the satisfaction of the programme co-ordinator.

It is a normal function of the programme co-ordinator to observe teachers in 'the art of teaching' and to do informal assessments of students' work. A satisfactory fulfillment of this objective was deemed to be the successful solution of two unrelated problems by the students. The programme co-ordinator (the writer) accepted the process as being successful when 100% of the students worked their way through the "seven steps" and reached a viable solution.

Objectives for students

1. Given all available data regarding a designated problem in society, and a model for problem-solving, be able to write a probable solution. The solution must account for and define all the various steps in the problem-solving process as contained in the given model.

The teacher determined whether the steps were being 'worked through'. The solution was examined by the teacher, principal, and programme co-ordinator to determine if the solution was one that could be accepted for this particular grade level. An endorsement from all three signified an acceptable solution.

2. Given three different socio-economic, political and legal problems confronting Canadian society, be able to write viable solutions using a given model as a guide to the satisfaction of a panel composed of the students, teacher, and programme co-ordinator.

This last objective involved the student in his/her own evaluation. As the teacher was previously involved in the solution strategy, the students at this point were expected to evaluate each other's work. This was completed through a process whereby the teacher and programme co-ordinator also shared in the evaluative decision making.

Description of Plans for Analysing Results

Since this is a process that is not amenable to most forms of statistical tests, judgements concerning acceptable levels of performance are outlined in the Objectives commentary (Chapter V). The form was observational research. Specifically, it included case study, situational analysis, team problem-solving and individual role playing. Progress (or lack of it) was logged and evaluated in a group setting as well as by the writer's observations.

An observational checklist was administered by the writer during in-class observation of each teacher after the first workshop/seminar in which problem-solving techniques were presented. The same observational checklist was administered by the writer during in-class observation of

each teacher after the second workshop/seminar in which problem-solving techniques was practiced.

Teachers recorded in journal format their participation in the problem-solving process. Teachers observed their peers modelling problem-solving techniques in a workshop setting. They critiqued the problem-solving process being modelled.

In the final month of implementation, teachers administered a problem-solving scenario to their students. The teachers recorded the percentage of students in each class who successfully worked through the problem-solving process. That data was recorded in table format.

Chapter IV

SOLUTION STRATEGY

Model Introduction

Strategic problem-solving demands the ability to specify a goal, generate alternative solutions for reaching that goal, evaluate the means and the consequences of each alternative, and select a solution which is then implemented and evaluated (Spivack et al., 1976, Rotheram, 1987, p. 206).

Jackson (1985) introduced "a list of principles for an approach to problem-solving" (pp. 12-13). The methodical approach is brought to bear "... dividing the work of problem-solving into stages and concentrating upon one stage at a time. This makes it easier to work efficiently and to apply further and more specific methods at the right time" (p. 14). Accepting Jackman's view, the model used by the writer was presented in a sequential stage. Dewey (1933) introduced the model upon which Jackson (1985) bases his "methodical approach" (p. 12). It was Dewey's recommendation that "... students be confronted with problems that they can relate to, to the end that they desire to pursue actively the resolution of the problem" (Tomlinson, 1987, p. 150). Adding more structure, Jackson (1985) formulated a number of stages that give direction and understanding to the sequence of operations. However, the number of stages into which the solving of a problem is divided is not a matter of great importance even though many

writers have suggested lists of stages with slight differences in number, meaning and emphasis. What really matters is that teachers should have a thorough understanding of the sequence of operations.

Jackson's (1985, p. 14) stages of problem-solving are:

1. Formulating the problem, which involves its detection, identification and definition.
2. Interpreting the problem.
3. Constructing courses of action.
4. Decision-making.
5. Implementation.

Skobel (1987) approached the sequence of operations in a similar manner but added emphasis to a hypothesis development. She states that "students in any classroom already know how to learn. The problem-solving method should provide a vehicle to encourage individualized learning and to develop and to expand the students knowledge" (p. 9). The problem-solving process as used by Skobel (1987, p. 11) is as follows:

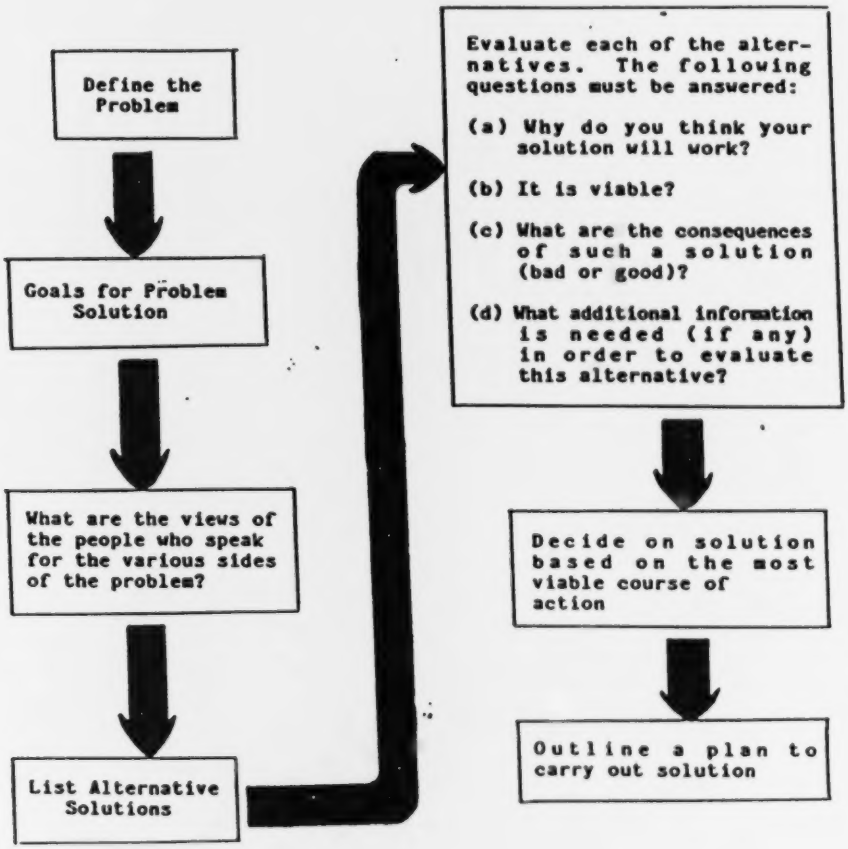
1. Define a problem.
2. Establish a tentative hypothesis.
3. Interpret the information available.
4. Gather additional information.
5. Analyze the information.
6. Synthesize the information.

Throughout the process Tomlinson (1987) and Skobel (1987) describe the teacher's role by referring to Dewey

(1933): "The teacher is a guide and director; he steers the boat, but the energy that propels it must come from those who are learning" (p. 615).

The writer's choice in the problem-solving process is as follows:

PROBLEM-SOLVING MODEL


Define the Problem
Goals for Problem Solution
What are the views of the people who speak for the various sides of the problem?
List Alternative Solutions
Evaluate each of the alternatives. The following questions must be answered:
(a) Why do you think your solution will work?
(b) It is viable?
(c) What are the consequences of such a solution (bad or good)?
(d) What additional information is needed (if any) in order to evaluate this alternative?
Decide on solution based on the most viable course of action
Outline a plan to carry out solution

Model format is based on Scully (1988)

This format is similar to both Jackson (1985) and Skobel (1987), yet different in the specific directions it provides. The model presented by the writer is one intended to be used by both teacher and student (regardless of ability). As such, the steps provided must be clear and precise.

Ross and Maynes (1982, pp. 5 - 7) established problem-solving skills that could be performed as an isolated task without reference to the other skills in the list.

1. Establishing a focus for the inquiry involves defining the elements of the problem to be solved or identifying the question to be answered.
2. Establishing a framework for the inquiry involves developing a mental image of the problem and its solution. The image of the problem includes the elements of the problem (like the focusing skill) and an understanding of the way in which these elements are connected.
3. Determining sources of data.
4. Obtaining data at source involves identifying relevant bits of data within a body of information and removing these bits for use in the investigation.
5. Judging the adequacy of data.
6. Putting data into a framework involves recording information in a format suitable for interpretation.

7. Reducing data to summary form involves simple calculations such as averaging, computing percentages, etc., to make it easier to interpret the information recorded in the framework.
8. Observing relationships in data involves examining the filled frameworks (such as a completed data table or a plotted graph) to find trends in the data.
9. Interpreting data.
10. Extrapolating the interpretation involves generalizing from one context to another or applying the conclusions reached with one set of cases to a different set of cases.
11. Communicating an inquiry involves reporting the results, and when relevant, the process of an investigation. This is the final product of a problem-solving episode.

These eleven skills have "general application to all problem situations but the relative importance of each skill varies with the type of problem. The dimensions of performance also vary with problem type" (Ross and Maynes, 1982, p. 7). This approach is intended for advanced problem-solving and as such is not that suitable for general usage.

To be successful at problem-solving, students need to be equipped with "the ability to think through issues and to make good decisions. The new curriculum provides this opportunity for learning: students should integrate content, understandings, and skills through the study and discussion of inquiries. The problem-solving method ...

provides a vehicle to encourage individualized learning and to develop and to expand the students knowledge" (Skobel, 1987, p. 9).

Beyer (1979) outlines six "essential elements" of problem-solving as a way of learning (pp. 31-32):

1. Start with a question or problem;
2. Guess at some possible answers or solutions;
3. Test the accuracy of the guesses against some evidence that one decided ought to exist and that was drawn out of available information (including background experience);
4. Judge how well this evidence corroborates the guesses;
5. State some guesses believed to be accurate, at least in terms of the available information; and
6. Apply new information as it becomes available to conclusions.

This process, as with the others, involves problem-solving as a form of systematic, purposeful thinking. As such it becomes an approach to learning in which "... all rational thinkers, problem-solvers, or reflective thinkers engage. [It] has as much use in resolving everyday personal problems ... as it has for resolving public policy issues or for learning in a classroom setting" (Beyer, 1979, p. 41). This approach is also supportive of the model presented by the writer.

Throughout the literature on problem-solving, there are many strategies that are identified as having been used in

a systematic manner to help solve problems. Although no single strategy can guarantee perfect solutions every time, Schoenfeld (1979) found that many educators and scientists claimed to use specific strategies and rules when solving problems. Many of the educators and scientists believe that students would solve problems better if they learned some basic skills for attacking problems (Halpern, 1984, p. 167). In addition, several researchers have found that instruction in general problem-solving skills can improve problem-solving ability (Klein and Weizenfeld, 1978; Halpern, 1984). Halpern's (1984) problem-solving strategies include the statement that "the best way to solve a problem is to devise the best representation" (p. 167). This forces the problem-solver to be explicit about the desired goal and to plan carefully the steps necessary to reach the goal. She presents the following "ways to represent problems" (pp. 167-198).

1. Write it down
2. Draw a graph or diagram
3. Try a hierarchical tree (a branching diagram)
4. Make a matrix
5. Manipulate models
6. Select the best representation
7. Conduct a means-ends analysis. This is a procedure by which problem-solvers select subgoals and use them to progress toward the goal. This is a forward-looking strategy where all of the planning is done by

considering operations that move the problem-solver closer to the subgoals and, ultimately, the final goal.

8. Develop a "working backward" strategy. That is, start with the goal and work backwards to the present. This is a good strategy to use whenever there are fewer paths leading from the goal.
9. Simplification. This is a strategy whereby much of the complexity of a problem is stripped away in order to reduce it to a simpler form.
10. Generalization and specialization. When confronting a problem, it is sometimes helpful to consider it as an example of a larger class of problems (generalization); or to consider it as a special case (specialization).
11. Trial-and-Error. This approach is best applied to well-defined problems with few possible solution paths.
12. Rules. Some kinds of problems, like series problems, depend on rules. Once the underlying principles are established, the problem is solved.
13. Brainstorming.
14. Contradiction. Halpern (1984) cites Wickelgren (1974) to show how the contradiction's method works: "the goal could not possibly be obtained from the givens, since it is inconsistent with the givens" (p. 194).
15. Restating the problem. This strategy is useful for ill-defined problems. In well-defined problems the goal is usually explicitly stated in unambiguous terms which leave little room for restatement.

The fifteen steps are valuable for teachers who might have difficulty in wording or defining "the problem" in the first step of the model. In addition, Halpern (1984, pp. 198-199) writes that: "It is important to keep in mind that these [fifteen] strategies are not mutually exclusive. It will often be best to use them in combinations. The best strategy or strategies depends on the nature of the problem. Along with each strategy the following "strategies for selecting strategies" should be applied:

1. If the problem is ill defined, try to restate the goal or the problem.
2. When there are very few possible solutions, a trial-and-error approach will work well.
3. If a problem is complete, try simplification, means-ends analysis, and generalization and specialization.
4. When there are fewer paths leading from the goal than there are from the start state, work backwards.
5. If you can gather additional information, do it. Look for and utilize hints.
6. If there is an ordered array of equally likely alternatives, try the split-half method and seek rules.
7. If the problem is a lack of possible solution paths, brainstorm to generate alternative solution paths.
8. Problems in Mathematics and logic are especially amenable to a solution by contradiction.
9. Use of analogies, metaphors and consulting an expert are widely applicable to all sorts of problems.

10. Remember that these are only guidelines to solving problems. The best way to be an expert problem-solver is to solve lots of problems.

Investigators have used two quite different methods for identifying effective problem-solving strategies that work (Nickerson, Perkins, and Smith, 1985; Schenfeld, 1980; and Scriven, 1980). One has been to study the performance of experts; the other has involved attempts to give problem-solving abilities to computers. Nickerson, Perkins, and Smith (1985) concluded that "the study of [expert] performance is an effective way to identify generally useful problem-solving strategies, but not the only one. The point that prescriptive approaches need not be descriptive of the approaches that people take spontaneously is well taken. Conversely, descriptions of how people, including experts, spontaneously approach problems are not always assured of providing the best bases for the development of prescriptions for success" (p. 70).

Larkin (1980) identifies a few general problem-solving strategies that appear repeatedly in computer programmes. They include: (1) means-ends analysis, which involves determining the difference between the current state of knowledge, about a problem and the state required to produce a solution, and selecting some action that will reduce the difference between these two knowledge states; (2) the kind of planning that involves replacing the original problem with a simplified version that retains only its central

features, solving this abstracted problem and using its solution to guide the search for a solution to the original problem; and (3) the replacement of temporarily unattainable goals with similar sub-goals. "Larken suggests that there is some evidence to indicate that these strategies are useful not only for well-defined tasks ... but also for solving problems of the types found in [the] classroom" (Nickerson, Perkins and Smith, 1985, p. 71). Nickerson, Perkins and Smith (1985) cite Polya's (1957) "classic treatise on problem-solving" (p. 74) to distinquish the four stages of problem-solving within a prescriptive model (p. 75):

1. Understand the problem.
2. Devise a plan. This involves formulating a general strategy, not a detailed proof. Formulation of such a strategy is an inductive process, not a deductive one.
3. Carry out the plan. This is the detailed proof, and here is where deductive reasoning comes in.
4. Look back, i.e. check your results.

In addition, the following heuristics are offered by Nickerson, Perkins, and Smith (1985, pp. 75-86) for the problem-solving process.

A. Heuristics for representing or understanding the problem:
    1. Make sure you understand the unknown, the data (i.e. the givens), and the conditions that relate the data.

2. Make sure you understand the nature of the goal state, the initial state and the permissible operations.
3. Draw a graph or diagramme and introduce suitable notation.
4. If the way of representing a problem does not lead to the solution, try to restate or reformulate the problem.

B. Heuristics for devising a plan:

1. Think of a known problem that is structurally analogous to the present one and try to solve that.
2. Think of a known problem that has the same kind of unknown but is simpler.
3. If you cannot solve the problem on which you are working, see if you can transform it into a problem whose solution you know.
4. Simplify the problem by looking at special cases.
5. Substitute specific values for the integer variable and see if any generalization appears. If it does, try to prove the generalization by induction.
6. Make the problem more general, and see if you can solve that.
7. Break the problem into parts. If the parts are not manageable, break those into smaller parts, continuing in this fashion until you arrive at problems of manageable size.

C. Heuristics for executing a plan:

1. Check each step.

D. Heuristics for checking results:

1. Try to solve the problem a different way.
2. Check the implications of your solution.

E. Heuristics for representing a problem:

1. Draw inferences about the initial and goal states, and add them to your representation.

F. Heuristics for a problem-solving failure:

1. If you cannot solve the problem on which you are working, see if you can transform it into a problem whose solution you know. (pp. 75-76)

Nickerson, Perkins and Smith (1985) make the claim that "the heuristics seem worth teaching: they have great range of applicability and hence should often be beneficial. Many of the heuristics are relatively well specified in the sense that they can be programmed into a computer and therefore should be communicable to students. Furthermore, there is some consensus that the heuristics ... are the ones that expert problem solvers really do use. Finally, ... there are sufficiently few heuristics that it is feasible to teach them" (p. 86).

Acknowledging the value of the heuristics, Knoop (1987) sets out "five steps to help you tackle problems and solve them" (p. 19). His five steps established "an approach that stresses how problems should be solved rather than how they are solved" (p. 17).

The method suggests that you structure the analysis of a problem situation along a five-step procedure (Knoop, 1987, p. 20):

Step 1: Identify and define the real problem

Step 2: Analyze and examine the problem thoroughly

Step 3: Develop and evaluate alternatives that solve the problem

Step 4: Decide on the best alternative

Step 5: Make an action plan

Knoop (1987) reports that those who have used the method in the past, either individually or with groups, have reported several benefits.

> Generally, as skills with the method improve so does the quality of solutions and the time required to arrive at them. Specifically, the method forces users to look at a problem situation carefully and objectively, to observe what is happening critically, to analyze facts and information surrounding the situation thoroughly, and to develop the ability to use incomplete information to arrive at a realistic assessment of what needs to be done. Conversely, the method prevents decision-makers from ignoring information about a problem and deciding on the basis of two or three obvious and familiar alternatives and from seeking out only facts that confirm their choice, ignoring facts that challenge it.

> The main function of the method is to guide thinking, to allow organization of one's thoughts sequentially, cohesively, and logically. It facilitates problem-solving and acts as a simplifying device (p. 19).

Description and Justification for Solution Selected

Gagné (1977) suggests that when an individual is engaged in a problem-solving operation, it is necessary to have learned a problem-solving operation, to have learned certain 'rules' (essential elements and skills), to have acquired certain 'concepts' which themselves have had to be learned through a process of 'discrimination'. Thus, problem-solving is the ability to use the rules and concepts at one's disposal in order to tackle situations which are new to the learner. Therefore, the solution involves teaching the rules and concepts, and using a model to provide structure and sequence.

A model is a representation of a system that gives shape, structure, and pattern to ideas about problem-solving that should hold these ideas in a lasting form. "In a very complicated situation, a model to look at and think about is essential for holding and displaying all the important features of the situation and their relationships, and without the mind it is as helpless as an orchestra with no score to play from" (Jackson, 1985 p. 65).

Thus, the strategies being advanced by the writer are those which embrace the heuristics of Nickerson, Perkins, and Smith (1985) and form a composite from the other cited researchers. Since the researchers cited do not take opposing views but are in general agreement about problem-solving, the writer relied on their specific suggestions as well.

The model being advanced is also a composite of the best points made throughout the literature, brought together in a manner that will serve the needs of the teachers and students. It simplifies many points and suggestions and places them into a structure that facilitates a 'step-by-step' movement through the problem-solving process (See Appendix B).

Having a model for novice problem-solvers can be a most invaluable tool. Schoenfeld (1979) demonstrated that students can increase their problem-solving abilities "by approximately three times" if they have a model to emulate (p. 141).

Given the model to emulate, the steps and heuristics in the problem-solving process to guide the way, the novice problem-solver should be able to take the first plunge into the world of inquiry.

The inservice sessions were designed to be goal oriented. Prior to the inservice sessions, all parties knew what the objectives were and had a common understanding respecting the extent to which these objectives were

expected to be satisfied. There was agreement that the attainment of the objectives was a realistic expectation. For this process to succeed, the appropriateness and mutual understanding of objectives constituted crucial considerations that cannot be overemphasized.

Because an inservice "session" may carry connotations of an event taking place within specific time limits, it was decided to speak in terms of an inservice experience, realizing that the totality of the experience may be designed to be completed over a period of time, utilizing a variety of "sessions" of the time-constrained variety.

The components that comprised the format for the inservice were as follows:

Theory. The theory component of the inservice experience included the rationale, the theoretical base, verbal descriptions, and model presentation. The presentation of the theory underlying problem-solving was intended to raise awareness and increase conceptual control.

Modelling. This component of the inservice involved the modeling of the teaching strategy (the model) through a demonstration of its use. Some teachers requested several repetitions of the modeling in order to develop the confidence that was needed in order to try the technique. Modeling appeared to have significant effect on both teacher awareness of the problem-solving techniques, and on the knowledge of it.

Modeling also assisted in the mastery of the theory.

Practice. This stage involved trying out the new skill under classroom conditions. Practice is a very efficient way of acquiring skills and strategies after the teacher has achieved awareness and knowledge. These were the "dry runs", which, combined with appropriate feedback, helped teachers to anticipate problems that might be encountered when they attempt to implement the new teaching notions into their regular teaching repetoire.

Feedback. Structured feedback involved using a procedure for observing teachers in a real situation. The program co-ordinator observed teacher using the problem-solving model in the classroom setting.

Coaching for Application. The coaching for application component included providing assistance to teachers in their attempts to analyze both the content to be taught and their use of the problem-solving model.

Chapter V

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

The first objective for teachers stated that: "Given a model for problem-solving be able to identify the steps in the problem-solving process without aid of references." Teachers were given a blank outline of the seven-step model in the form of a means/ends block diagramme (Appendix E). Teachers were expected to fill in all seven-steps without the aid of references.

Twelve teachers were given the blank outline of the seven-step model and allocated ten minutes for the exercise. The results were as follows:

Table 2

RESULTS OF MODEL USAGE

Exercise	Number of Teachers	Number of Teachers Succeeding
#1	12	9
#2	12	11
#3	12	12

For complete mastery of this exercise, sufficient time (the opportunity to learn) was provided, along with appropriate materials and instruction. It took three attempts before 100% of the teachers could achieve the objective. Mastery of the objective by teachers was

considered essential before progressing to the level whereby teachers would be modeling in the classroom.

The next step in the process of mastering the objectives was for each teacher "to role-model the methodologies with such a degree of proficiency so that [their] peers [could] identify the steps in the problem-solving process". This required each teacher to role-play the classroom setting for their peers. Together, teachers explored feelings, attitudes, values, and problem-solving strategies.

Role playing in the context of this objective was designed specifically to foster: (1) the development of practice sessions for the purpose of increasing proficiency in the use of the model; and (2) the development of empathy toward others using the model (both teacher and student).

The performance of each teacher was evaluated by his peers. The role-playing performance was considered acceptable when each observing member (teacher) could identify the steps used by the teacher in the problem-solving process. In addition, teachers critically examined each other's performances in light of their appropriateness to the classroom setting.

The role-playing activities provided each teacher with the opportunity to find personal meaning in the use of the model and to resolve dilemnas (role-playing both teacher and student) with the assistance of the peer group. The evaluation tool for the role-playing activities was known as

the Criteria for Acceptable Modelling (See Appendix D). The criteria were simple given that just two questions were required to be answered. A 'yes' or 'no' response to the performance determined if it was acceptable. A considerable amount of discussion usually followed each performance. The purpose of the discussion was to analyze each teacher's work with an eye to duplication at the classroom level. Teachers were normally very critical, in a constructive sense, of each performance. Only those performances that clearly showed a mastery of the model were acceptable.

This exercise proved to be most beneficial to teachers as it gave them confidence to proceed at the classroom level. All of the teachers reported "confidence building" as the beneficiary of this activity.

After completion of the inservice and peer tutoring sessions, the next step became the first exposure of the problem-solving model at the classroom level.

Each student was given the model and directed to apply it to any social studies problem requiring a solution. Before students actually applied the model it was modelled by the teacher to a hypothetical situation. The students naturally asked questions concerning the model but reported finding it to be "very practical and easy to follow".

The initial exposure was considered successful when 100% of the students could work their way through the seven steps in the model and reach a viable solution. The

decision as to whether this process was achieved was determined by the programme co-ordinator (the writer).

The second step required the students to work through a similar process with a different problem focus. This second attempt by the students was evaluated by the teacher, principal, and programme co-ordinator 'to determine if the solution was one that reflected this particular grade level'. After an average of four attempts by each student, an endorsement by all three evaluators was given for an acceptable solution.

The students also evaluated their own work with an eye to determining whether their problem-solving skills had "increased", "stayed the same", or "decreased" as a result of model usage. One hundred percent of the students stated that their "problem-solving skills had increased", with ninety-two percent indicating that their skills had increased to a point where they would "feel comfortable in any problem-solving situation".

The student results told the story -- the problem-solving process had been a success. Each step in the practicum process had been completed and the stated objectives had been realized.

The final step was a summary statement by each participant as to why the objectives were achieved with some much ease. The response by each participant was unanimous -- they felt "ownership to the solution strategies". Since the original problem was first brought to the attention of

the writer by the teachers and since it was the teachers themselves who first prescribed the solution strategy (problem-solving model), they were acutely committed to a successful conclusion. This gave the teachers a stake in the future of a collective enterprise. A sense of ownership seems critical to the practicum's success for two reasons. First, student achievement usually suffers at the hands of teachers who are not committed to a programme they are teaching (CSDE, 1980; McLaughlin and March, 1978). Second, ownership on a collective basis permits administrative co-ordination of instructional programmes, a characteristic frequently cited in the distinction between effective and ineffective schools (CSDE, 1980; Glenn and McLean, 1981; Venesky and Winfield, 1979).

Conclusions

Rosenholtz (1985) makes the point that teacher participation in technical decision making is the "stuff of collegial interaction" (p. 374). Participation implies a commitment to the instructional program, better curriculum development through the adaptation of curricular material to specific classroom needs, and increased student learning resulting from greater teacher effectiveness. It would appear that this was the case here.

There is ample evidence that the approach to problem-solving experienced through this practicum process leads to improved learning. Evidence in terms of students'

favourable response to problem-solving is more anecdotal than statistical. Teachers involved in the process report that students greet the activities and materials with genuine enthusiasm and work through the exercises with diligence. The most important factor is that students find direction in using a model. There is very little wondering about "What are we supposed to do?" or "What do we do next?" The feeling of mastering a task provides a powerful incentive for students to be attentive to demands.

Teachers who participated in the pilot have been very positive about the experience. The two most important reasons for this teacher reaction is the response of students and their own sense of ownership to the solution.

The writer cannot guarantee success for all those who may employ the model in their teaching. The key determinant of success will hinge on teachers commitment to the process. The student learning that results from this process will impress the novice teacher, and, more importantly, it will impress students.

Recommendations

The recommendations emanating from the practicum's results and conclusions are as follows:

That the use of a model will enhance the problem-solving abilities of students in social studies;

That the use of a model will increase teacher effectiveness in teaching problem-solving skills;

That the first step in the problem-solving process be one which establishes a sense of ownership by teachers to the solution;

That heuristics for representing a problem be established to facilitate the use of a model;

That heuristics for devising a solution strategy be established;

That heuristics for a problem-solving failure be established.

Dissemination

The model developed during the practicum process has been incorporated into the Canadian Issues course throughout the school district. Many classes have the model displayed in their classroom as a ready guide through the problem-solving process. The success experienced by both teachers and students have generated interest by those teachers who have not been directly involved in any previous problem-solving techniques. Consequently, the writer has been invited to present his work at a district social studies conference and to the provincial social studies council. A

decision has already been made to include a problem-solving component to each social studies course for grade three through to grade nine. The success rate for those grades will determine whether it will be extended to grade twelve.

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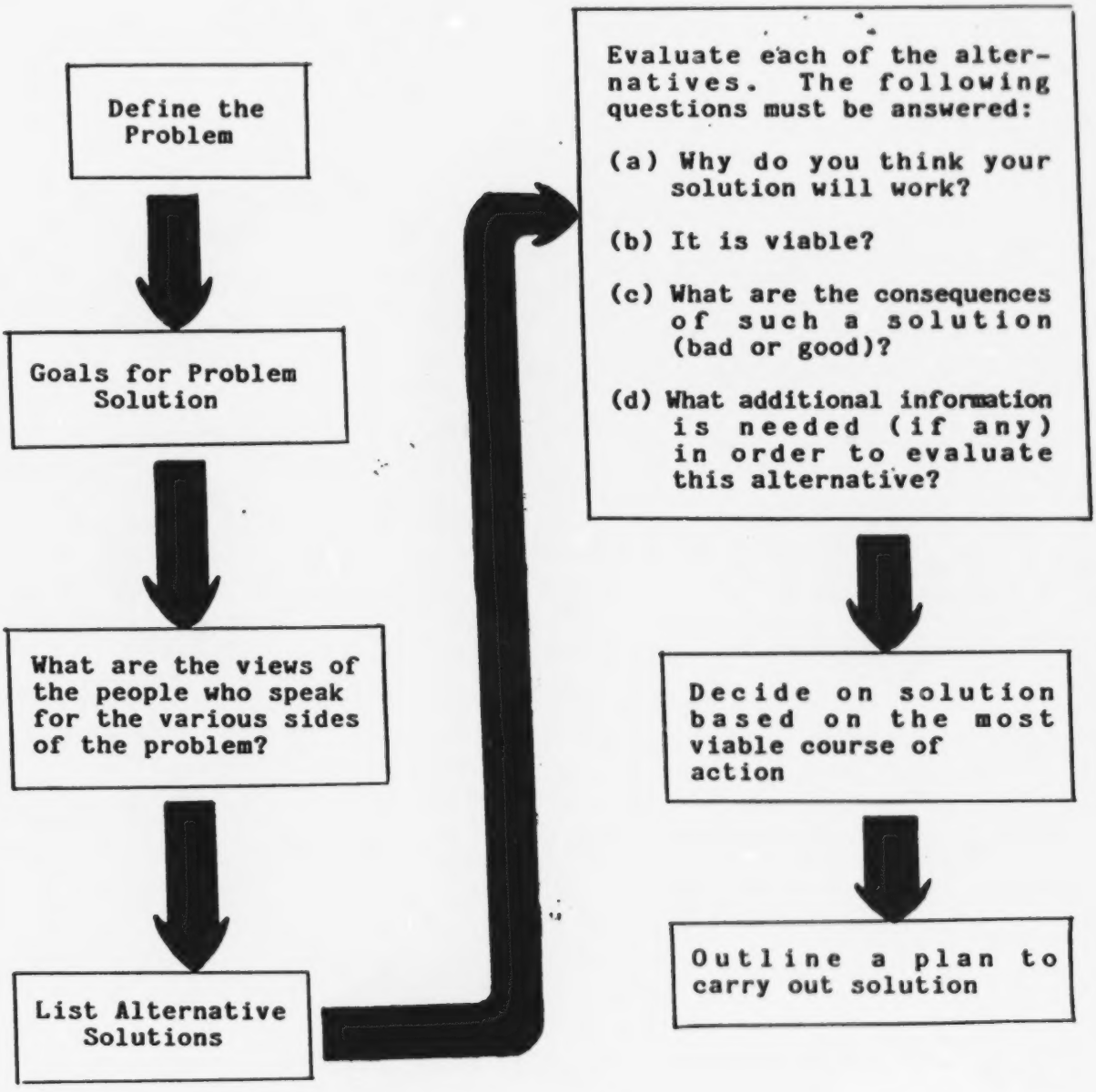
Appendix A

TEACHER PROBLEM-SOLVING INTERVIEW QUESTIONS

1. Have you received any university/college training in problem-solving teaching strategies?
2. Have you attended workshops or in-service sessions specifically on Social Studies problem-solving? How many and when?
3. How would you like Social Studies programmes to handle problem-solving?
4. How important do you think problem-solving should be in the Social Studies curriculum? Why?
5. What are the major obstacles to your teaching problem-solving in Social Studies?
6. Should problem-solving techniques be taught interspersedly or be concentrated in a unit on problem-solving, or both? Why?
7. Is there any final statement you would like to say or add about problem-solving in Social Studies?

Appendix B

PROBLEM-SOLVING MODEL


Define the Problem
Goals for Problem Solution
What are the views of the people who speak for the various sides of the problem?
List Alternative Solutions
Evaluate each of the alternatives. The following questions must be answered:
(a) Why do you think your solution will work?
(b) It is viable?
(c) What are the consequences of such a solution (bad or good)?
(d) What additional information is needed (if any) in order to evaluate this alternative?
Decide on solution based on the most viable course of action
Outline a plan to carry out solution

Model format is based on Scully (1988)

Appendix C

OBSERVATIONAL CHECKLIST

1. Is the teacher following the necessary steps/heuristics in the problem-solving process? yes no

2. Is the teacher following the steps in the model? yes no

3. Can the steps being followed by the teacher in the problem-solving process be readily identified? yes no

4. Is the teacher sequentially proceding through the model? yes no

5. Is the interaction between teacher and student conducive to a problem-solving environment? yes no

6. Are the students exhibiting problem-solving skills? yes no

Appendix D

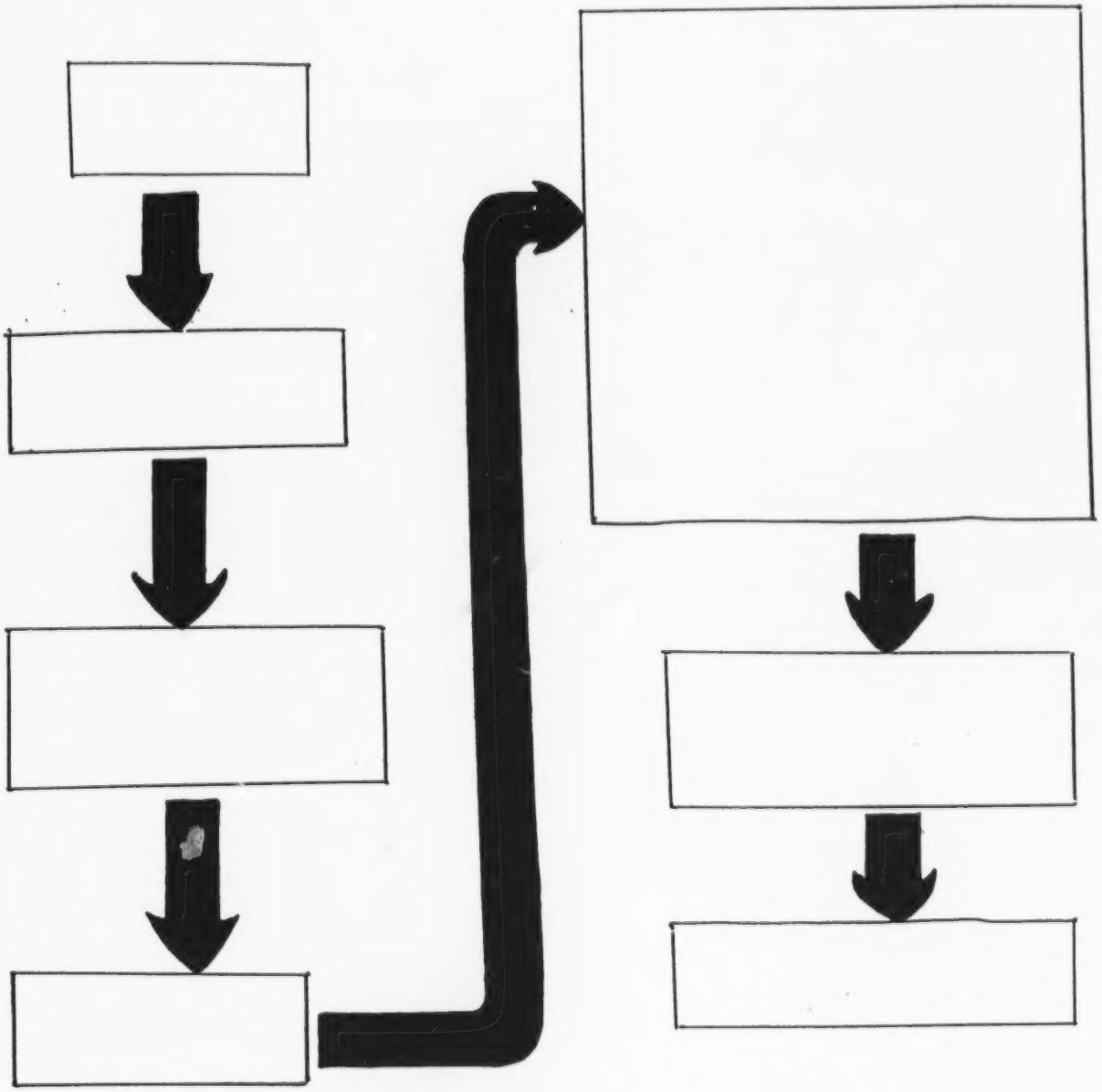
CRITERIA FOR ACCEPTABLE MODELLING

1. Is the teacher working through the steps in the problem-solving process? yes no

2. Is the derived solution to the identified problem recognized as being viable? yes no

Appendix E

PROBLEM-SOLVING MODEL



Model format is based on Scully (1988)